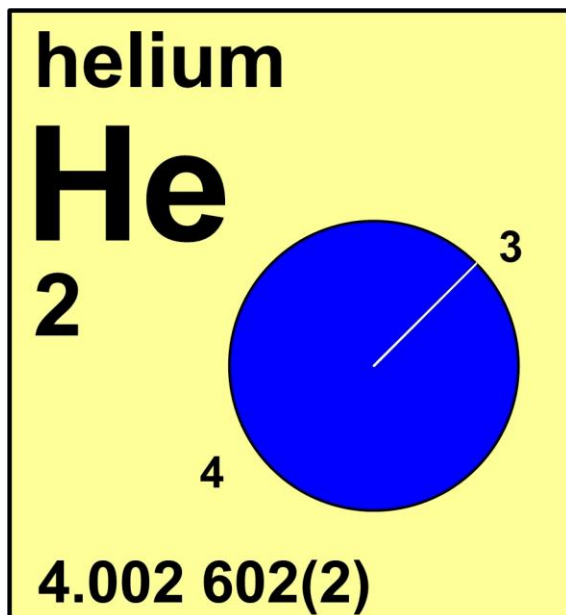


helium



Stable isotope	Atomic mass*	Mole fraction
^3He	3.016 0293 191	0.00000134
^4He	4.002 603 254 15	0.99999866

* Atomic mass given in unified atomic mass units, u.

Half-life of radioactive isotope

Less than 1 second
Between 1 second and 1 hour
Greater than 1 hour



Important applications of stable and/or radioactive isotopes

Isotopes in geochronology

- ^3He is a product of radioactive decay of ^3H (half life 12.32 years). Measurements of the ratio of $^3\text{He}/^3\text{H}$ can be interpreted in terms of elapsed time. This has been especially useful in aquatic systems like oceans, lakes, and aquifers that received large inputs of ^3H from precipitation following thermonuclear bomb test periods. ^3H - ^3He dating provides elapsed time since a water mass became isolated from the atmosphere, in the time range from the mid-1950s to the present. Such studies are important for establishing the sustainability of groundwater resources in shallow aquifers.
- ^4He is a product of radioactive decay in the U and Th decay series. As a result, ^4He concentrations can be used to estimate the relative ages of minerals and groundwaters. In closed systems, for example, measurements of $^4\text{He}/\text{U}$ can be interpreted in terms of elapsed time, although other processes can alter the distribution of He, which is highly mobile in terrestrial environments. ^4He concentrations commonly increase along groundwater flow paths through cumulative release from natural aquifer materials. This rate of accumulation can be used to estimate groundwater age. The ^4He accumulation method of groundwater dating typically can be used in deeper aquifers where groundwater is relatively old, where the ^3He - ^3H method cannot be used.

Isotopes in industry and medicine

- 1) Special properties of the ^3He isotope are used in many different applications. ^3He has a large effective cross-section for neutron absorption, which makes it especially useful for radioactivity detection. In this application, neutrons produced by radioactive decay of elements such as U and Pu enter the detector where they react with ^3He to produce ^1H and ^3H atoms, inducing further collisions and release of electrons, which interact with charged surfaces to generate electric current. Large amounts of ^3He are used to produce neutron detectors in portal monitors for detecting illicit radioactive materials at ports, border crossings, and airports (Figure 1).
- 2) ^3He neutron detectors also are used in devices that determine proportions of water, oil, and gas in wells drilled for energy production.
- 3) Other important uses of ^3He include lasers used for missile guidance and space navigational systems, cryogenic research (ultra-low temperature, $< 1\text{K}$), and magnetic resonance imaging of the lungs (Figure 2).
- 4) The global supply of ^3He available for research and practical applications has become severely limited in recent years, such that prices have increased and some uses have been curtailed. A major source of ^3He is recovery from nuclear weapons containing ^3H , when the warheads are reconditioned or dismantled. ^3He accumulates in such devices as a radiogenic product of ^3H decay. The annual supply of new ^3He has decreased along with reductions in nuclear arsenals.



Figure 1: Radiation detectors are installed in many areas to screen people, vehicles, and cargo for radioactive materials. ^3He detectors are sensitive to thermal neutrons and can be used to detect isotopes of uranium and plutonium that might be used in nuclear weapons, along with other sources that produce neutrons by radioactive decay. Replacements for ^3He neutron detectors are being developed because ^3He gas takes up a lot of volume and because ^3He is becoming scarce and expensive. Potential replacements under study include solid compounds containing other neutron absorbers such as ^{10}B or ^6Li .

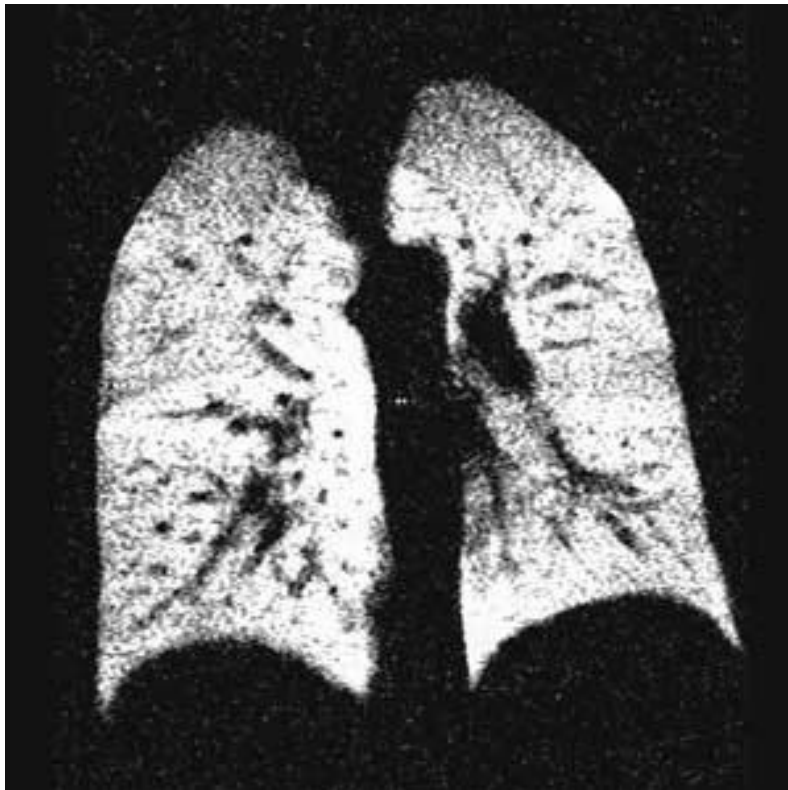


Figure 2: Polarized ^3He in conjunction with MRI is used to study chronic obstructive pulmonary diseases (COPD), and to test the efficacy of COPD drugs. Image of lungs of nonsmoker.